Industries and Spin-offs

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In the late 1960s, many of America's aerospace companies were on the brink of economic disaster. The problems stemmed from cutbacks in the space agency's budget and significant declines in military and commercial orders for aircraft. President Richard Nixon's approval of the Space Shuttle Program came along just in time for an industry whose future depended on securing lucrative NASA contracts.

The competition for a piece of the new program was fierce. For the Space Shuttle Main Engines, the agency selected North American Rockwell's Rocketdyne Division. The biggest financial contract of the program, estimated at $2.6 billion, also went to North American Rockwell Corporation to build the Orbiter. The announcement was one bright spot in a depressed economy, and California-based Rockwell allocated work to rivals in other parts of the country. Grumman of Long Island, New York, which had built the Lunar Module, constructed the Orbiter's wings. Fairchild Industries in Germantown, Maryland, manufactured the vertical tail fin. NASA chose Martin Marietta of Denver, Colorado, to build the External Tank, which would be manufactured at the Michoud Assembly Facility in Louisiana. Thiokol Chemical Corporation, based in Utah, won the Solid Rocket Motor contract. In addition to these giants, smaller aerospace companies played a role. Over the next 2 decades, NASA placed an increased emphasis on awarding contracts to small and minority-owned businesses, such as Cimarron Software Services Inc. (Houston, Texas), a woman-owned business.

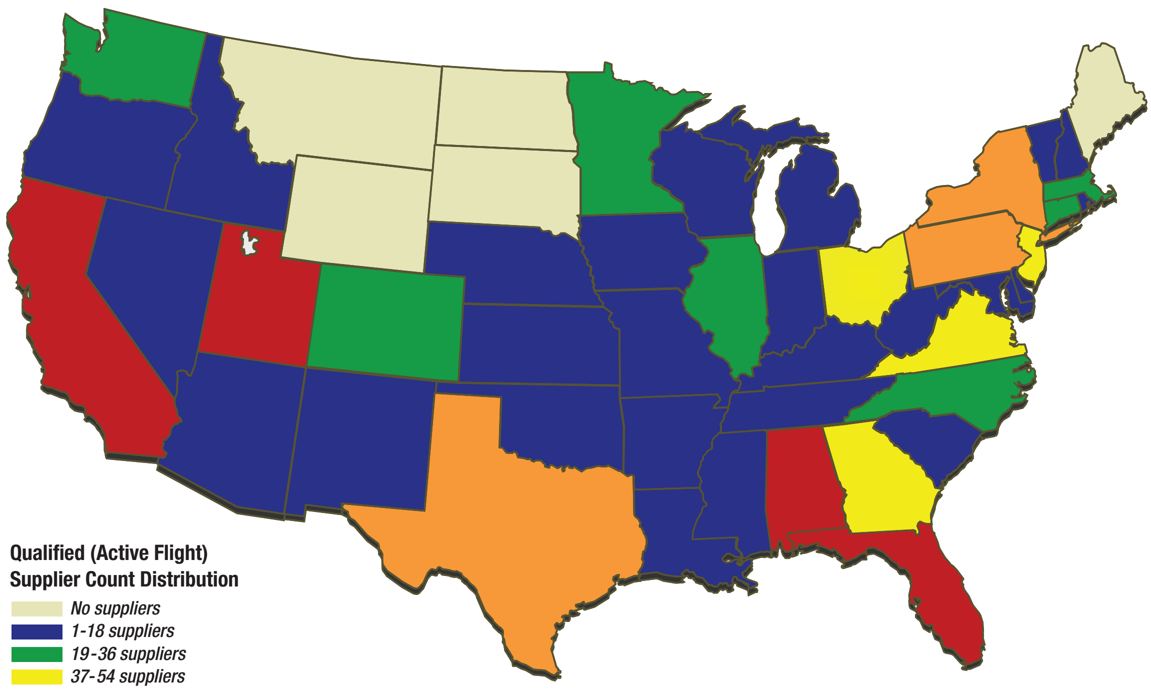
Shuttle engineering and science sparked numerous innovations that have become commercial products called spin-offs. This section offers seven examples of such technological innovations that have been commercialized and that benefit many people. Shuttle-derived technologies, ranging from medical to industrial applications, are used by a variety of companies and institutions.

Industries

Aerospace Industry

Concurrent with the emphasis placed on reduced costs, policy makers began studying the issue of privatizing the shuttle and turning over routine operations to the private sector. Complete and total privatization of the shuttle failed to come to fruition, but economic studies suggested that contract consolidation would simplify oversight and save funds. In 1980, NASA decided to consolidate Kennedy Space Center (KSC) contracts, and 3 years later, KSC awarded the Shuttle Processing Contract. Johnson Space Center followed KSC's lead in 1985 by awarding the Space Transportation System Operations Contract, which consolidated mission operations work. Industry giants Lockheed and Rockwell won these plums.

Space Shuttle Program Active Flight Hardware Suppliers Distribution by State—12/30/00 to 12/30/04



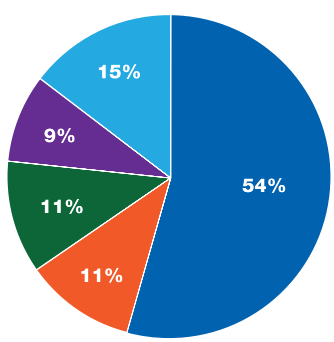
Qualified (Active Flight) Supplier Count Distribution

- *No suppliers*
- *1-18 suppliers*
- *19-36 suppliers*
- *37-54 suppliers*
- *55-72 suppliers*
- *72+ suppliers*

Number of Supplier Companies per Major Component

Orbiter	*817*
Main Engines	*147*
Solid Rocket Boosters	*119*
Motors	*147*
External Tank	*68*
Total	***1,541***

Space Shuttle Program by Contractor—Fiscal Year 2007 – $2.932 Billion



- *United Space Alliance—Space Program Operations Contract*
- *Lockheed Martin—External Tank and Missions Operations Contract*
- *Alliant Techsystems/Thiokol—Solid Rocket Booster Motor Contract*
- *Pratt & Whitney Rocketdyne—Shuttle Main Engine Contract*
- *Other Contracts—Jacobs Technology; InDyne, Inc.; Computer Sciences Corporation; and SGS*

Wyle Laboratories, Inc. works with scientists for the payloads on Neurolab (STS-90 [1998]). The experiment shown is the kinematic, eye tracking, vertical ground reaction force study in March 2002. In the foreground are test operators Chris Miller (left) and Ann Marshburn. The test subject in the harness is Jason Richards and the spotter is Jeremy House.

NASA introduced a host of new privatization contracts in the 1990s to further increase efficiency in operations and decrease costs.

Over the years, companies provided the day-to-day engineering for the shuttle and its science payloads. For instance, Hamilton Sundstrand and ILC Dover were instrumental companies for spacesuit design and maintenance. Lockheed Martin and Jacobs Engineering provided much of the engineering needed to routinely fly the shuttle. Both Lockheed Martin and Wyle Laboratories, Inc. are examples of companies that assured the science payloads operations were successful.

Commercial Users

US industry, aerospace, and others found ways to participate in the Space Shuttle project. Hundreds of large and small companies provided NASA with hardware, software, services, and supplies. Industry also provided technical, management, and financial assistance to academia pursuing government-granted science and technology research in Earth orbit. Yet, a basic drive of industry is to develop new, profitable business.

Beginning in the late 1970s, NASA encouraged American businesses to develop profitable uses of space. This meant conceiving of privately funded, perhaps unique, products for both government and commercial customers—termed “dual use”—as well as for purely commercial consumers. While several aerospace companies were inspired by earlier work in American space projects, a few had ideas for the use of space entirely founded in the unique characteristics of orbital spaceflight. These included launching commercial-use satellites, such as two communications satellites—Anik C-2 and Palapa Bl—launched from Space Transportation System (STS)-7 (1983). The shuttle phased out launching commercial satellites after the Challenger accident in 1986.

Non-aerospace firms, such as pharmaceutical manufacturers, also became interested in developing profitable uses for space. Compared to those of previous spacecraft, the capabilities of the shuttle provided new opportunities for innovation and entrepreneurship. Private capital was invested because of these prospects: regular transport to orbit; lengthy periods of flight; and, if needed, frequent human-tended research and development. Even before the first flight of the shuttle, US private sector businesses were inquiring about the vehicle’s availability for industrial research, manufacturing, and more, in space.

During the 30-year Space Shuttle Program, companies interested in microgravity sciences provided commercial payloads, such as a latex reactor experiment performed on STS-3 (1982). These industry-funded payloads continued into the International Space Station Program.

Although the shuttle did not prove to be the best vehicle to enhance commercial research efforts, it was the stepping-stone for commercial use of spacecraft.

Small Businesses Provided Critical Services for the Space Shuttle

As of 2010, government statistics indicated that almost 85% of Americans were employed by businesses with 250 employees or fewer. Such "small businesses" are the backbone of the United States. They also play an important role in America's space program, and were instrumental during the shuttle era. For example, the manufacture and refurbishment of Solid Rocket Motors required the dedication and commitment of many commercial suppliers. Small business provided nearly a fourth of the total dollar value of those contracts. Two examples include: Kyzen Corporation, Nashville, Tennessee; and PT Technologies, Tucker, Georgia.

Kyzen Corporation enabled NASA's goal to eliminate ozone-depleting chemicals by providing a cleaning solvent. This solvent, designed for precision cleaning for the electronics industry, was ideal for dissolving solid rocket propellant from the manufacturing cleaning tooling. The company instituted the rigid controls necessary to ensure product integrity and eliminate contamination.

PT Technologies manufactured precision-cleaning solvent with non-ozone-depleting chemicals. This solvent was designed for use in the telephone and electrical supply industry to clean cables. It also proved to perform well in the production of Solid Rocket Motors.

Small business enterprises are adaptive, creative, and supportive, and their partnerships with NASA have helped our nation achieve its success in space.

A mixing tank used to produce the cleaning solvent for dissolving solid rocket propellant at Kyzen Corporation. This solvent was free of ozone-depleting chemicals.

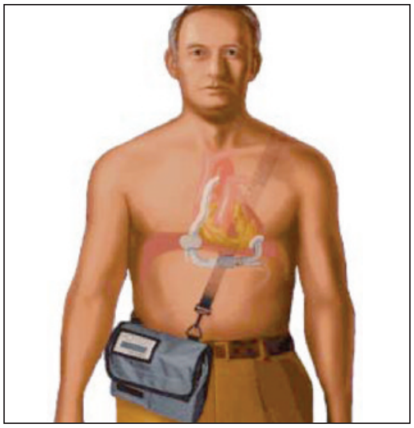
Spin-offs

NASA Helps Strengthen the "Bridge for Heart Transplants"

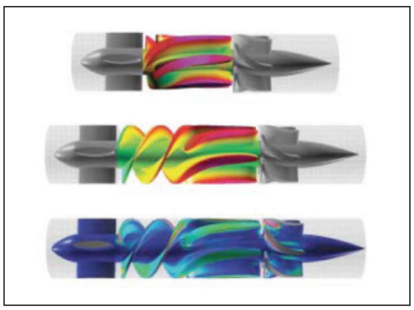
Innovation can occur for many reasons. It can arise from the most unlikely places at the most unlikely times, such as at the margins of disciplines, and it can occur because the right person was at the right place at the right time. The story of David Saucier illustrates all of these points.

Dave Saucier sought medical care for his failing heart and received a heart transplant in 1984 from Drs. DeBakey and Noon at the DeBakey Heart Center at Baylor College of Medicine, Houston, Texas. After his transplant, Dave felt compelled to use his engineering expertise and the expertise of other engineers at Johnson Space Center (JSC) to contribute to the development of a ventricular assist device (VAD)—a project of Dr. DeBakey, Dr. Noon, and colleagues. A VAD is a device that is implanted in the body and helps propel blood from the heart throughout the body. The device was intended to be a bridge to transplant. This successful collaboration also brought in computational expertise from NASA Advanced Supercomputing Division at Ames Research Center (Moffett Field, California).

This far-reaching collaboration of some unlikely partners resulted in an efficient, lightweight VAD. VAD had successful clinical testing and is implemented in Europe for children and adults. In the United States, VAD is used in children and is being tested for adults.



The DeBakey VAD® functions as a "bridge to heart transplant" by pumping blood throughout the body to keep critically ill patients alive until a donor heart is available.



These illustrations show a visual comparison of the original ventricular assist device (top) and the unit after modifications by NASA researchers (center and bottom). Adding the NASA improvements to the MicroMed DeBakey VAD® eliminated the dangerous backflow of blood by increasing pressure and making flow more continuous. The highest pressure around the blade tips are shown in magenta. The blue/green colors illustrate lower pressures.

So, what was it that Dave Saucier and the other engineers at JSC thought they knew that could help make a VAD work better, be smaller, and help thousands of people seriously ill with heart failure and waiting for a transplant? Well, these folks had worked on and optimized the turbopumps for the shuttle main engines that happen to have requirements in common with VAD. The turbopumps needed to manage high flow rates, minimize turbulence, and eliminate air bubbles. These are also requirements demanded of a VAD by the blood and body.

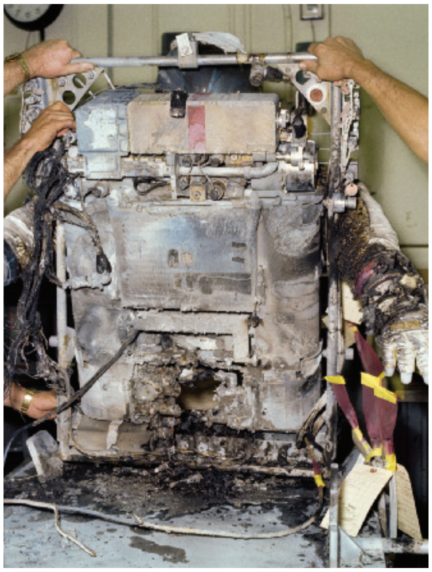
In the beginning, VADs had problems such as damaging red blood cells and having stagnant areas leading to the increased likelihood of blood clot development. Red blood cells are essential for carrying oxygen to the tissues of the body. Clots can prevent blood from getting to a tissue, resulting in lack of oxygenation and buildup of toxic waste products that lead to tissue death. Once engineers resolved the VAD-induced damage to red blood cells and clot formation, the device could enter a new realm of clinical application. In 1996 and 1999, engineers from JSC and NASA Ames Research Center and medical colleagues from the Baylor College of Medicine were awarded US patents for a method to reduce pumping damage to red blood cells and for the design of a continuous flow heart pump, respectively. Both of these were exclusively licensed to MicroMed Cardiovascular, Inc. (Houston, Texas) for the further development of the small, implantable DeBakey VAD®.

MicroMed successfully implanted the first DeBakey VAD® in 1998 in Europe and, to date, has implanted 440 VADs. MicroMed's HeartAssist5® (the 2009 version of the DeBakey VAD®) weighs less than 100 grams (3.5 oz), is implanted in the chest cavity in the pericardial space, which reduces surgical complications such as infections, and can operate for as many as 9 hours on battery power, thereby resulting in greater patient freedom. This device not only acts as a bridge to transplant, allowing patients to live longer and better lives while waiting for a donor heart, it is now a destination therapy. People are living out their lives with the implanted device and some are even experiencing recovery, which means they can have the device explanted and not require a transplant.

Making Oxygen Systems Safe

Hospitals, ambulances, industrial complexes, and NASA all use 100% oxygen and all have experienced tragic fires in oxygen-enriched atmospheres. Such fires demonstrated the need for knowledge related to the use of materials in oxygen-enriched atmospheres. In fact, on April 18, 1980, an extravehicular mobility unit planned for use in the Space Shuttle Program was destroyed in a dramatic fire during acceptance testing. In response to these fire events, NASA developed a test method and procedures that significantly reduced the danger. The method and procedures are now national and international industrial standards. NASA White Sands Test Facility (WSTF) also offered courses on oxygen safety to industry and government agencies.

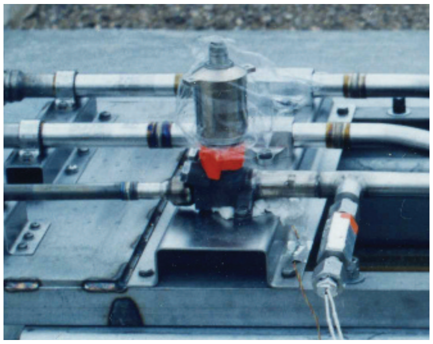
During the shuttle era, NASA made significant advances in testing and selecting materials for use in high-pressure, oxygen-enriched atmospheres. Early in the shuttle era, engineers became concerned that small metal particles could lead to ignition if the particles were entrained in the 277°C (530°F) oxygen that flowed through the shuttle's Main Propulsion System gaseous oxygen flow control valve. After developing a particle impact test, NASA determined that the stainless-steel valve was vulnerable to particle impact ignition. Later testing revealed that a second gaseous oxygen flow control valve, fabricated from an alloy with nickel chromium, Inconel® 718, was also vulnerable to particle impact ignition. Finally, engineers showed that an alloy with nickel-copper, Monel®, was invulnerable to ignition by particle impact and consequently was flown in the Main Propulsion System from the mid 1980s onward.




The original shuttle extravehicular mobility unit with an aluminum secondary oxygen pack isolation valve and first-stage regulator ignited and burned during acceptance ground testing on an unoccupied unit in 1980 (left). The redesigned unit with a nickel-copper alloy secondary oxygen pack isolation valve and first-stage regulator is being used with much success (right).

NASA's activities led to a combustion test patent (US Patent Number 4990312) that demonstrated the superior burn resistance of a nickel-copper alloy used in the redesigned, high-pressure oxygen supply system. Member companies of the American Society for Testing and Materials (ASTM) Committee G-4 pooled their resources and requested that NASA use the promoted combustion test method to determine the relative flammability of alloys being used in industry oxygen systems. Ultimately, this test method was standardized as ASTM G124.

NASA developed an oxygen compatibility assessment protocol to assist engineers in applying test data to the oxygen component and system designs. This protocol was codified in ASTM's Manual 36 and in the National Fire Protection Association *Fire Protection Handbook*, and has gained international acceptance.



Pretest.

Ignition by particle impact.

This gaseous oxygen valve was found to be vulnerable to ignition when small metal particles were ingested into the valve. The test method developed for this is being used today by the aerospace and industrial oxygen communities.

Another significant technology transfer from the Space Shuttle Program to other industries is related to fires in medical oxygen systems. From 1995 through 2000, more than 70 fires occurred in pressure-regulating valves on oxygen cylinders used by firefighters, emergency medical responders, nurses, and therapeutic-oxygen patients. The Food and Drug Administration approached NASA and requested that a test be developed to ensure that only the most ignition- and burn-resistant, pressure-regulating valves be allowed for use in these medical systems. With the help of a forensic engineering firm in Las Cruces, New Mexico, the WSTF team developed ASTM G175, entitled *Standard Test Method for Evaluating the Ignition Sensitivity and Fault Tolerance of Oxygen Regulators Used for Medical and Emergency Applications*. Since the development and application of this test method, the occurrence of these fires has diminished dramatically.

This spin-off was a significant development of the technology and processes to control fire hazards in pressurized oxygen systems. Oxygen System Consultants, Inc., in Tulsa, Oklahoma, OXYCHECK™ Pty Ltd in Australia, and the Oxygen Safety Engineering division at Wendell Hull & Associates, Inc., in Las Cruces, New Mexico, are examples of companies that performed materials and component tests related to pressurized oxygen systems. These businesses are prime examples of successful technology transfer from the shuttle activities. Those involved in the oxygen production, distribution, and user community worldwide recognized that particle impact ignition of metal alloys in pressurized oxygen systems was a significant ignition threat.

Preventing Land Mine Explosions—Saving Lives with Rocket Power

Every month, approximately 500 people—including civilians and children—are killed or maimed by accidental contact with land mines. Estimates indicate as many as 60 to 120 million active land mines are scattered across more than 70 countries, including areas where hostilities have ceased. Worldwide, many of the more than 473,000 surviving victims require lifelong care.

In 1990, the US Army solicited existing or short-term solutions to in-field mine neutralization with the ideal solution identified as a device that was effective, versatile, inexpensive, easy to carry, and easy to use, but not easily converted to a military weapon.

Rocket Science—An Intelligent Solution

The idea of using leftover shuttle propellant to address this humanitarian crisis can be traced back to late 1998 when shuttle contractor Thiokol (Utah) suggested that a flare, loaded with propellant, could do the job. To validate the concept, engineers tested their idea on small motors. These miniature rocket motors, no larger than a D-size battery, were used in research and development efforts for ballistics characterization. With some refinements, by late 1999, the flare evolved into a de-mining device that measures 133 mm (5 in.) in length by 26 mm (1 in.) in diameter, weighs only 90 grams (3.2 oz), and burns for approximately 60 seconds. NASA and Thiokol defined an agreement to use the excess propellant.

The Thiokol de-mining flare used excess shuttle propellant resulting from Solid Rocket Motor casting operations to burn through land mine casings and safely ignite the explosives contained within. The flares were activated with an electric match or a pyrotechnic fuse.

Ignition Without Detonation—How It Works

The de-mining flare device is ignited by an electric match or a pyrotechnic fuse; it neutralizes mines by quickly burning through the casing and igniting the explosive fill without detonation. The benefit of this process includes minimizing the destructive effect of demolition, thereby preventing shrapnel from forming out of metallic and thick-cased targets. The flares are simple and safe to use, and require minimal training. The flare tube can be mounted on a three-legged stand for better positioning against the target case.

These de-mining flares were tested against a variety of mines at various installations. These trials went well and generated much interest. Thiokol funded further development to improve production methods and ease deployment.

All branches of the US armed services have purchased the flare. It has been successfully used in Kosovo, Lebanon, Jordan, Ethiopia, Eritrea, Djibouti, Nicaragua, Iraq, and Afghanistan, and has been shown to be highly effective.

LifeShear Cutters to the Rescue—Powerful Jaws Move Life-threatening Concrete

Hi-Shear Technology Corporation of Torrance, California, used NASA-derived technology to develop a pyrotechnic-driven cutting tool that neutralized a potentially life-threatening situation in the bombed Alfred P. Murrah Federal Building in Oklahoma City, Oklahoma, in April 1995. Using Jaws of Life™ heavy-duty rescue cutters, a firefighter from the Federal Emergency Management Agency Task Force team sliced through steel reinforcing cables that suspended an 1,814.4-kg (2-ton) slab of concrete, dropping the slab six stories. It took only 30 seconds to set up and use the cutters.

The shuttle used pyrotechnic charges to release the vehicle from its hold-down posts on the launch pad, the Solid Rocket Boosters from the External Tank after their solid fuel was spent, and the tank from the shuttle just prior to orbit. This type of pyrotechnical separation technology was applied in the early 1990s to the development of a new generation of lightweight portable emergency rescue cutters for freeing accident victims from wreckage. Known as LifeShear cutters, they were developed under a cooperative agreement that teamed NASA and Hi-Shear Technology Corporation. Hi-Shear incorporated this pyrotechnic feature into their Jaws of Life™ heavy-duty rescue cutters. The development project was undertaken to meet the need of some 40,000 US fire departments for modern, low-cost emergency cutting equipment.

Hi-Shear Technology Corporation developed, manufactured, and supplied pyrotechnically actuated thrusters, explosive bolts, pin pullers, and cutters, and supplied such equipment for a number of NASA deep-space missions plus the Apollo/Saturn, Skylab, and shuttle.

The key technology for the LifeShear cutter is a tailored power cartridge—a miniature version of the cartridges that actuated pyrotechnic separation devices aboard the shuttle. Standard cutting equipment employs expensive gasoline-powered hydraulic pumps, hoses, and cutters for use in accident extraction. The Jaws of Life™ rescue tool requires no pumps or hoses, and takes only about 30 seconds to ready for use. It can sever automotive clutch and brake pedals or cut quickly through roof posts and pillars to remove the roof of an automobile. Firefighters can clear an egress route through a building by cutting through reinforcement cable and bars in a collapsed structure situation.

NASA-developed tool, licensed under the name "LifeShear," used at the bombed Alfred P. Murrah Federal Building (1995), Oklahoma City, Oklahoma.

Kennedy Space Center engineers conduct wire fault testing using portable Standing Wave Reflectometer. From left to right: Ken Hosterman; John Jones; and Pedro Medelius (inventor).

The Ultimate Test Cable Testing Device

It's hard to imagine, when looking at a massive launch vehicle or aircraft, that a problem with one tiny wire could paralyze performance. Faults in wiring are a serious concern for the aerospace and aeronautic (commercial, military, and civil) industries. The shuttle had circuits go down because of faulty insulation on wiring. STS-93 (1999) experienced a loss of power when one engine experienced a primary power circuit failure and a second engine had a backup power circuit fault. A number of accidents occurred as a result of faulty wiring creating shorts or opens, causing the loss of control of the aircraft or arcing and leading to fires and explosions. Some of those accidents resulted in loss of lives, such as in the highly publicized TWA Flight 800 accident in 1996.

With the portable Standing Wave Reflectometer cable tester, it was possible to accurately pinpoint malfunctions within cables and wires to reliably verify conditions of electrical power and signal distribution. This included locating problems inside shuttle. One of its first applications at Kennedy Space Center (KSC) was to detect intermittent wire failures in a cable used in the Solid Rocket Boosters.

The Standing Wave Reflectometer cable tester checked a cable with minimal disruption to the system under test. Personnel frequently had to de-mate both ends of cables when troubleshooting a potential instrument problem to verify that the cable was not the source of the problem. Once a cable was de-mated, all systems that had a wire passing through the connector had to be retested when the cable was reconnected. This resulted in many labor-hours of revalidation testing on systems that were unrelated to the original problem. The cost was exorbitant for retesting procedures. The same is true for aeronautical systems, where airplanes have to be checked frequently for faulty cables and sensors. The most useful method and advantage of the Standing Wave Reflectometer technology over other existent types of technologies is the ability to measure from one end of a cable, and to do comparative-type testing with components and avionics still installed.

Eclypse International Corporation, Corona, California, licensed and marketed two commercial versions of the Standing Wave Reflectometers based on the prototype designed and patented by KSC. One called ESP provided technicians with a simple, plain-English response as to where the electrical fault was located from the point at which the technicians were testing. A second product, ESP+, provided added memory and software for looking at reflections from the aircraft, which was useful in determining some level of "soft fault"—faults that are not open or shorted wires.

The technology was evaluated by the US Navy, US Marines, and US Air Force to test for its ruggedness for deployment in Afghanistan. The country was known for a fine grade of sand and dusty conditions—a taxing combination rarely found in the United States. The model underwent operational evaluation by the US Navy, US Marines, and US Air Force, and the US Army put these instruments into the battle damage and repair kits that went to Afghanistan, Iraq, and other parts of the world where helicopter support is required. This innovation has proved to be versatile in saving time and lives.

The Ultimate Test

In Bagram, Afghanistan, October 2004, one particular Northrop Grumman EA-6B Prowler aircraft was exhibiting intermittent problems on a critical cockpit display panel. To make matters worse, these problems were seldom seen during troubleshooting but occurred multiple times on nearly every flight. It was a major safety problem, especially when flying at night in a war zone in mountainous terrain. Squadron maintainers had been troubleshooting for weeks, changing all associated removable components and performing wire checks with no discernable success. After approximately 60 hours of troubleshooting, which included phone consultation with engineering and the manufacturer of the electronic system that was providing intermittent symptoms, the Naval Air Technical Data & Engineering Service Command decided to try the Standing Wave Reflectometer and immediately observed a measured change of conductor length as compared with similar paths on the same aircraft. Technicians were able to isolate the problem and replace the faulty wire.

Keeping Stored Water Safe to Drink—Microbial Check Valve

The Space Shuttle system for purifying water has helped the world's need for safe water, especially for disaster situations, backpackers, and remote water systems where power and active monitoring were limited. This well-tested system, called the Microbial Check Valve, is also used on the International Space Station. This valve is ideal for such applications since it can be stored for a long period of time and is easily activated.

The licensee and co-inventor, with NASA, of the Microbial Check Valve was Umpqua Research Company (Myrtle Creek, Oregon). The system was used on all shuttle flights to prevent growth of pathogens in the crew drinking water supply. The valve is a flow-through cartridge containing an iodinated polymer, which provides a rapid contact microbial kill and also imparts a small quantity of dissolved iodine into the effluent stream. This prevents further microbial growth and maintains water safety.

The Microbial Check Valve—measuring 5.1 cm (2 in.) in diameter, 12.7 cm (5 in.) in length—is a stainless-steel cylinder with connections on its ends that facilitated its installation in the shuttle water system line. The cylinder is packed with iodinated ion exchange resin (the base resin is Dowex SBR®). A perforated plate backed by a spring presses against the resin and keeps it compacted to prevent short-circuiting of the water as it flows through the resin.

Treatment of uncontrolled microbial growth in stored water was essential in the shuttle because water was produced through the fuel cells of oxygen and hydrogen, and the resultant water was stored in large tanks. The shuttle was reused and, therefore, some residual water always remained in the tanks between launches. Iodine, like chlorine, prevents microbial growth, is easy to administer, and has long-life effectiveness as it is much less volatile than chlorine.

The innovation was a long-shelf-life iodinated resin. When water passed through the resin, iodine was released to produce acceptable drinking water. This system inactivated seven bacteria, yeasts and molds and three different viruses, including polio. The costs were also very reasonable.

The volume of the resin in the valve was selected to treat five 30-day shuttle equivalent missions (3,000 L [793 gal]: based on 2.8 L [0.7 gal]/day/person use rate for a seven-person crew) for the maximum shuttle fuel cell water production rate of 120 L (31.7 gal)/hr. All in-flight-produced water flowed through the microbial check valve to impart a small iodine residual to prevent microbial growth during storage and back contaminations, further contributing to the safety and purification of drinking water during shuttle missions.

"Green" Lubricant—An Environmentally Friendly Option for Shuttle Transport

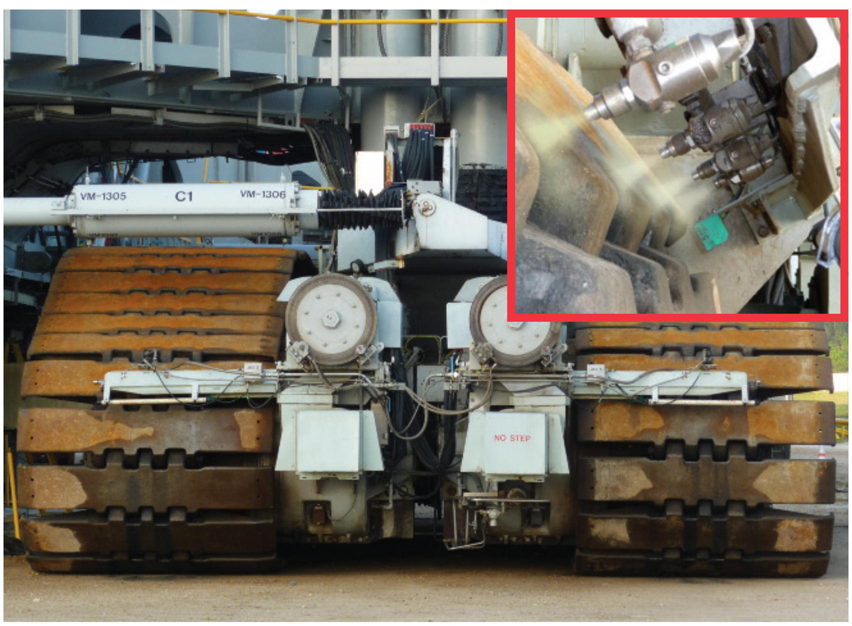
In the mid 1990s, NASA uncovered an environmental problem with the material used to lubricate the system used to transport the shuttle. The agency initiated an effort to identify an environmentally friendly lubricant as a replacement.

The Mobile Launcher Platform at KSC provided a transportable launch base for the shuttle. NASA used a vehicle called a "crawler" with a massive track system to transport the platform and a shuttle. During transport, lubricants had to withstand pressures as high as 5,443 metric tons (6,000 tons). Lubrication reduced wear and noise, lengthened component life, and provided protection from corrosive sand and heat.

NASA personnel injected low-viscosity lubricant on the pins that structurally linked 57 individual track "shoes" together to form an individual tread belt. Periodic application during transport minimized crankshafting of individual pins inside the shoe lug holes, thus reducing the risk of structural damage and/or failure of the tread belt system. The performance parameters of the original lubricant resulted in a need for operators to spray the pins approximately every mile the transporter traveled.

Lockheed Martin Space Operations, NASA's contractor for launch operations at KSC, turned to Sun Coast Chemicals of Daytona, Inc. (Daytona Beach, Florida) for assistance with co-developing a biodegradable, nontoxic lubricant that would meet all Environmental Protection Agency and NASA requirements while providing superior lubricating qualities. Sun Coast Chemicals of Daytona, Inc. assembled a team of researchers, production personnel, and consultants who met with NASA personnel and contractors. This team produced a novel formulation that was tested and certified for trial, then tested directly on the crawler.

The new lubricant—Crawler Track Lube—had a longer service life than previous lubricants, and was injected at longer intervals as the transporter was being operated. Additionally, the product was not an attractive food source to wildlife. Success with its initial product and the Crawler Track Lube led to an industrial product line of 19 separate specialty lubricants.



The Mobile Launch Platform transported the shuttle to the launch pad. Inset photo shows the dispenser that injects the lubricant on the pins, which are necessary for the treadbelt.